EFFECT OF CERTAIN RADIO WAVES ON INSECTS AFFECTING CERTAIN STORED PRODUCTS*

JOHN HADJINICOLAOU, M.S., HONORARY FELLOW**
DEPARTMENT OF ENTOMOLOGY, RUTGERS UNIVERSITY

INTRODUCTION

Headlee and Burdette (1) have shown that when certain representatives of the Hymenoptera, Diptera, Coleoptera, Lepidoptera and Orthoptera orders are subjected to radio waves promulgated in an electro-static field at a frequency of 12,000,000 cycles per second and an amperage of $1\frac{3}{4}$ amperes they are destroyed. In the honey bee they have shown that this destruction was due to the production of internal heat of a lethal degree. In the same insect they have also shown that the rate of producing this internal heat seems to be in part connected with nervous reaction. The intensity or field strength of the electrostatic field used by these workers has since been determined. For *Apis mellifera* it is 1,585 volts per linear inch, for *Glypta* 1,410, for *Musca domestica* and *Diabrotica 12-punctata* 1,570, and for *Pieris rapae* and *Periplaneta germanica* it was 1,410. Headlee (2) has shown that the principal variable physical factors underlying these lethal effects are apparently field strength, which is commonly expressed in terms of volts per linear inch, and frequency, measured in terms of cycles per second, that the optimum frequency for insects falls between 1,000,000 and 3,000,000 cycles per second at a field strength of about 4,000 volts per linear inch, and that there seems to exist a very considerable margin of safety between the power necessary to kill insects promptly and the power which will do damage to plants.

EFFECT ON INSECTS AFFECTING DRY FIGS, APRICOTS, PEPPER AND OTHERS

Having in mind the data set forth in the above discussion we proceeded to the study of the effect of high frequency radio

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waves on insects affecting stored products. Although the main object of this study is to show the effect of these radio waves on bean weevils, some data on the effect on some other insects will be given below. Between the aluminum test plates a glass tube four inches long and one half inch in diameter was suspended. The chemical composition of the glass as given by the manufacturer was the following.

AL_2O_3	2.0
Fe_2O_3	0.25
MnO	0.01
CaO	0.29
MgO	0.06
Na_2O	4.4
K_2O	0.2
SiO_2	80.5
B_2O_3	11.8
As_2O_5	0.7

The results are shown in table 1.

TABLE 1

Insect	Frequency in Cycles Per Second	Strength of Field in Volts Per Inch	No. of Runs	No. of Insects	Time to Kill in Minutes
Plodia interpunctella ..... Naked larvæ	1,090,000	3977.16	10	30	0 –35″
Plodia interpunctella ..... Larvæ in the fig	1,090,000	3977.16	10	30	2′–30″
Carpocapsa saltitans ..... Mexican Jumping beans) Naked larvæ	1,090,000	3977.16	3	9	1′– 5″
Carpocapsa saltitans ..... Larvæ in the beans	1,090,000	3977.16	6	18	3′– 0″
Sitodrepa panicea	1,090,000	3977.16			
Larvæ			10	30	1′–30″
Pupæ			10	30	2′– 0″
Popillia japonica ..... Grubs in the soil	1,090,000	3977.16	10	30	3′–30″

This table shows that insects affecting stored products are killed when subjected to high frequency radio waves. Larvæ of *Plodia interpunctella* affecting dry figs, apricots, etc., and larvæ and pupæ of *Sitrodrepa panicea* affecting ground pepper are killed when subjected to these waves for a period of time ranging from two minutes to two minutes and thirty seconds.

EFFECT ON BEAN WEEVILS, BRUCHUS 4–MACULATUS FAB.

Bruchus 4-maculatus Fab., belongs to the family Bruchidæ of the order Coleoptera. The weevils are very short and robust measuring about $\frac{1}{8}$ inch in length. The color is usually dark gray. The eggs are very small and white in color. The grubs are of a light creamy color and very small, a number of them being able to occupy a single bean. The pupæ are darker in color. The beetles under favorable conditions breed in stored beans over winter and in the springtime when the plant beans are in bloom, they fly and lay their eggs upon the pods. Upon hatching the young larvæ bore through the pod, reach the beans and then enter into them by drilling a hole which is very small to be easily distinguished. In the store the beetles lay their eggs singly on the beans. When the insects reach the adult stage they cut circular holes and emerge.

There are many generations each year. The beetles under favorable conditions breed enormously in the stored beans and render them altogether unfit for food or planting. Some times the embryo is devoured and the seeds do not germinate at all. Some times the cotyledons are devoured and the young embryo has not the necessary nutritious elements to grow until the plant will form its roots and become self-supporting.

It is of primary importance therefore to plant healthy seeds, free from any infection of bean weevils.

A complete line on the effect of high frequency radio waves on bean weevils and the possibility of a successful treatment of infested beans was worked out. Beans heavily infested with the bean weevil (*Bruchus 4-maculatus* Fab.) were obtained. Eggs, larvæ, pupæ and adults were present at the same time. A number of lots, 25 beans each were put one after another in a glass tube and subjected to high frequency waves for 2, 3, 4,

and 5 minutes respectively. One lot of 25 beans was left untreated to serve as a check.

These beans were put in small bottles and placed in the incubator with a constant temperature of 82° F. and moisture of 73 per cent. They were left in there from the twenty-first of October to the twenty-eighth of November, that is to say for a period of 38 days. In that period of time we could have a complete life cycle of the insect. Observations were made twice a day; all the emerging insects were recorded and taken out of the bottles.

Table 2 shows the results.

TABLE 2

No. of Days from Treatment to Examination	Numbers of emerged adults				
	Untreated Check	Treated for 2 minutes	Treated for 3 minutes	Treated for 4 minutes	Treated for 5 minutes
7	2	.....	...	...	...
11	3	2	...	...	...
12	2	1	...	...	...
14	2	1	1	...	...
15	3	.....	...	...	...
16	3	1	...	...	...
17	3	1	...	...	...
18	4	3	...	1	...
19	8	.....	2	...	...
21	4	1	...	...	...
22	3	3	2	...	...
23	1	.....	1	...	...
24	.....	2	...	1	...
25	2	.....	...	1	...
26	1	.....	...	...	...
28	1	.....	1	...	...
30	1	.....	...	...	...
33	2	3	1	...	...
35	1	1	...	...	...
36	.....	.....	...	...	...
38	.....	.....	...	...	...
Total Emergence	46	19	8	3	0

Examination of this table serves to show that all stages of the bean weevils are killed when the beans are subjected to a frequency of 1,087,000 cycles per second for five minutes with a strength of field of 4,000 volts per linear inch.

EFFECT ON SEED

The next step was to find out if the seeds thus treated lost their vitality or not. A variety of seeds, which usually are attacked by bean weevils or other similar insects, were treated for from two minutes up to 45 minutes. A set of five seeds of each of the following varieties except *Lentilla lens* (where a set consisted of 10 examples) was employed for each time period. After that they were planted in pots in the greenhouse. The seeds thus treated were: *Vicia faba* (Egyptian beans); *Phaseobus vulgaris* (common beans); *Phaseobus dolichus* (black eye bean); and *Lentilla lens* (lentils).

The seeds were put in glass tubes and suspended between the aluminum test plates. They were subjected to the radio waves for a time ranging from two to forty-five minutes. On the same day of the treatment the seeds were planted in pots and placed in the greenhouse. After a few days the seeds germinated to the proportion of 100 per cent. giving up perfectly healthy plants just as the untreated seeds did. Table 3 shows the results.

TABLE 3

Kinds of Seeds	No. of Seeds in Each Set	Treatment Time in Minutes for Each Set	Days Between Treatment and Coming Up	Per cent. Germination
Vicia faba	5	2, 3, 4, 5, 10, 20, 30, 35, 40, 45	5	100
Phaseobus vulgaris	5	5, 10, 15, 30, 45	5	100
Phaseobus dolichus	5	5, 10, 15, 30, 45	5	100
Lentilla lens	10	2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45	4	100

The bean weevils are killed when subjected to these radio waves for five minutes. The seeds are not destroyed even if they be subjected for 45 minutes or more. The heat accumulated in the insects is great enough to kill eggs, larvæ, pupæ and adults of *Bruchus 4-maculatus* but in the plants not high enough to damage the embryo of the seed.

CONCLUSIONS

The following conclusions may be drawn from the data submitted.

1. Certain insects subjected to high frequency radio waves are killed on account of the internal temperature which reaches a lethal point.

2. Larvæ of *Plodia interpunctella* affecting dry figs, apricots, etc., and larvæ and pupa of *Sitrodrepa panicea* affecting ground pepper are killed when subjected to these waves for a period of time ranging from two minutes to two minutes and thirty seconds.

3. All stages of the bean weevil (*Bruchus 4-maculatus* Fab.) are destroyed when subjected for five minutes to a frequency of 1,087,000 cycles per second with a field strength of 4000 volts per linear inch.

4. Treated seeds do not lose their germinating power. They may be planted and thus the damage due to infestation is eliminated.

REFERENCES

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